Evaluation of Pilot Treatment Effluents from Summitville Mine, CO., Using *Ceriodaphnia dubia*, Fathead Minnow (*Pimephales promelas*),and Rainbow Trout (*Oncorhynchus mykiss*) Toxicity Tests.

Lazorchak, J.M.*, U.S. EPA, Cincinnati, OH, Smith, M.E.[1], SoBran Environmental, c/o U.S. EPA Cincinnati.OH., Bates, E. U.S. EPA, Cincinnati, OH., Miller, G. Tetra Tech, Denver, CO.

ABSTRACT

As part of a Superfund Innovative Technology Evaluation (SITE) Program, the U.S. Environmental Protection Agency evaluated a remediation technology at the Summitville Mine Superfund Site in southern Colorado. The technology evaluated was a successive alkalinity producing system (SAPS) for removing high concentrations of metals (aluminum, copper, iron, manganese, and zinc). Two treated and one untreated water sample were evaluated using a series of acute aquatic toxicity tests with the fathead minnow *(Pimephales promelas)* and the daphnid *(Ceriodaphnia dubia)* and a subchronic 7-day survival and growth toxicity test using rainbow trout *(Oncorhynchus mykiss)*. All tests used moderately hard reconstituted water as the control and dilution water. The fathead minnows used in this study were three days old, the *C. dubia* were <24 H old, and the rainbow trout used were 18 days old, 5 days post swimup. The trout tests were conducted at 15^{0}C, the two other species were tested at 20^{0}C. *C. dubia* were more sensitive than rainbow trout, which were more sensitive than the fathead minnow. Both treated mine discharge samples displayed reduced toxicity of approximately 7-8 fold for *C. dubia*, 10 fold for rainbow trout, and about 5 fold for the fathead minnow. However, in order to remove all the acute toxicity from the mine discharge, a 1000 fold reduction in metals in both treatments would be needed for *C. dubia* survival, a 100 fold more reduction in the concentration of metals would be needed for rainbow trout survival, and a 50 fold reduction for fathead minnow survival.

INTRODUCTION

The U.S. Environmental Protection Agency has many programs for evaluating various methods to treat contaminated waste discharges. As part of a Superfund Innovative Technology Evaluation (SITE) Program, the USEPA evaluated a remediation technology at the Summitville Mine Superfund Site in southern Colorado. USEPA has instituted a program to develop a treatment system that will reduce the level of contamination, and therefore toxicity, of the wastewater discharged from this site. The technology evaluated was a successive alkalinity producing system (SAPS) for removing high concentrations of metals (aluminum, copper, iron, manganese, and zinc).

Three water samples from the Summitville Remediation site were shipped to the U.S. EPA Laboratory in Cincinnati, Ohio. These consisted of one untreated mine discharge sample (SW 01) and two discharge samples from the SAPS treatment technology (SW 04 and RCW). A series of acute aquatic toxicity tests with *Pimephales promelas*, fathead minnow and *Ceriodaphnia dubia*, a freshwater invertebrate, and chronic aquatic toxicity tests with *Oncorhynchus mykiss*, rainbow trout, were conducted on these samples. The purpose of these tests was to establish the level of toxicity for the discharge from the mine site and to evaluate the effectiveness of the treatment processe currently being used. The samples were also analyzed chemically. This data was used in conjunction with the toxicity data, to develop target levels of reduction for various analytes, including aluminum, copper, managanese and zinc. Developing these target levels for specific analytes provides goals for the designers to reach chemically, before additional resources are expended performing toxicity evaluations.

MATERIALS and METHODS

The acute toxicity tests were 48H static renewal tests that followed standard procedures described in the USEPA acute toxicity testing methods manual, EPA/600/4-90/027F. The *Oncorhynchus mykiss*, Rainbow trout, tests were 7-day chronic survival and growth tests. This is a method currently under development and the methods used were based on a Standard Operating Procedure developed in-house by USEPA-NERL-Cincinnati. The *P. promelas* and *C. dubia* used in these tests were from a culture maintained at the USEPA-NERL-Cinn. The trout used in these tests were obtained from TroutLodge, a hatchery facility located in Sumner, WA. The trout were held on-site at the EPA-NERL-Cinn culture facility for 3 days prior to the start of the test.

Table 1 contains a summary of the test conditions used for all three test species.

TABLE 1 Standard Operating Procedures for acute and chronic toxicity tests for Superfund samples.

TEST CRITERIA	SPECIFICATIONS		
	P. promelas	*C. dubia*	*O. mykiss*
Test Type	Static-renewal	same	same
Test Duration	48 hr	same	7 days
Temperature	20°C ± 1°C	same	15°C ± 1°C
Photoperiod	16 hr light/8 hr Dark	same	same
Test Chamber Size	175 ml	30 ml	500 ml
Test Solution Volume	150 ml	15 ml	400 ml
Renewal of Test sol	Daily	same	same
Age Organisms	3 to 7 days ± 24 hr age range	<24 H old	15 to 20 days old, 1 to 5 days post swimup
Num of Organisms/ per test chamber	10	5	5
Number of Replicate-Chambers/Conc.	2	4	4
Num of Organisms/ Concentration	20	20	20
Feeding	None	None	Feed 0.1 ml newly hatched Brine Shrimp 2X daily
Dilution Water	Moderately Hard Reconstituted Water	same	same
Endpoint	Mortality, LC50	same	survival and growth, IC25
Test Acceptability	≥90% control survival	same	same and control growth 1.5X the initial animal wt.

DATA ANALYSIS

All LC50 values were determined using Trimmed Spearman-Karber, version 1.5, which adjusts for control mortality. The Survival No Observed Acute Effect Level (NOAEL) the chronic survival No Observed Effect Concentration (NOEC) and the chronic growth NOEC were determined using Dunnett's, version 1.5, and the IC25 values were determined using ICp version 2.0.

Estimated Levels of Reduction for Target Analytes

The toxicity data were used to estimate the levels of reduction in the amount of each target analyte required so that the samples would not be acutely or chronically toxic to the species tested.

1) Multiply the level of each target analyte by the acute No Observed Acute Effect Level (NOAEL) for the C. dubia and/or P. promelas. This provides an estimated analyte level that would not cause acute toxicity.

2) Multiply the level of each target analyte by the chronic survival and growth No Observed Effect Level (NOEL) for the O. mykiss. This provides an estimated analyte level that would not cause chronic toxicity.

Sample Designations and Descriptions

SW-01 Discharge from Reynolds Adit. Influent for treatment system.
SW-04 Effluent discharge from SAPS treatment system.
RCW Effluent discharge from SAPS treatment system, after further treatment in the Rock Channel polishing system.

Diagram 1 shows the SAPS system as well as the sampling locations after each treatment process.

Diagram 1. Schematic Diagram of the Successive Alkalinity Producing System (SAPS) used to treat the Mine Waste Discharge at the Summitville Mine Site.

SAPS Treatment System Process Flow Schematic

Figure 1. Comparison of selected chemical analytes before and after treatment.

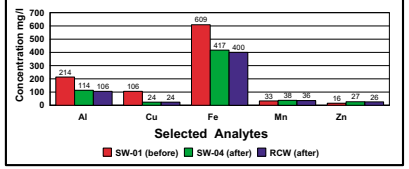


Figure 2. Comparison of LC50 and IC25 Values in SW-01 (untreated) SW-04 and RCW (both treated). Species tested were *C. dubia* (Cd), *P. promelas* (Pp) and *O. mykiss* (Om).

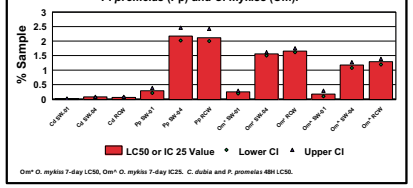


Figure 3. Comparison of Acute NOAEL and Chronic NOEC values for each Species Tested.

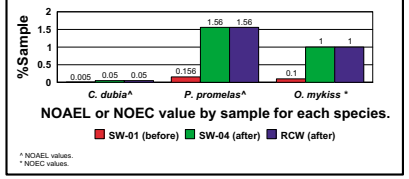


Figure 4. Estimated Acceptable Metals Levels Based on the NOAEL for Acute C. dubia.

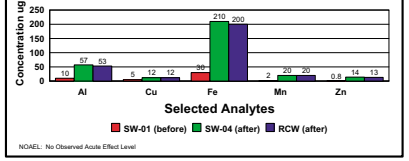


Figure 5. Estimated Acceptable Metals Levels Based on the NOAEL for *P. promelas*.

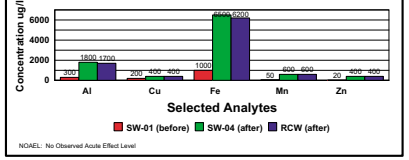
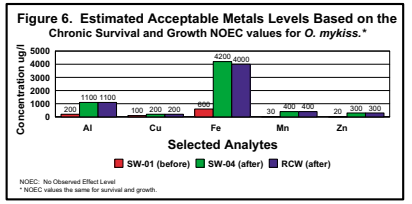


Figure 6. Estimated Acceptable Metals Levels Based on the Chronic Survival and Growth NOEC values for *O. mykiss*.*



KEY RESULTS

- The treatment system reduced the level of the target analytes, except zinc and Manganese (Figure 1).
- Treatment of the discharge water did reduce the toxicity of the water to all species tested (Figures 2 and 3).
- The estimated levels for each target analyte that would be below the acute toxicity effect level for *C. dubia* are shown in Figure 4. This is the goal the designers need to achieve for the best overall survival of the species tested.
- The estimated levels for each target analyte that would be below the acute toxicity effect level for *P. promelas* are shown in Figure 5.
- The estimated levels for each target analyte that would be below the chronic survival and growth toxicity effect levels for *O. mykiss* are shown in Figure 6. Achieving this goal would provide the best overall protection for the fish species.

CONCLUSIONS

- Evaluation with toxicity testing did reveal reductions in toxicity related to the use of the treatment system.
- Data from the toxicity tests can be used to estimate additional targets for reduction of target analytes.
- Use of multiple species allows the development of interim goals, or the use of a tiered approach, for reductions in the levels of the target analytes.

REFERENCES

- USEPA, 1993, Methods for Measuring the Acute Toxicity Of Effluents and Receiving Waters to Freshwater and Marine Organisms. EPA/600/4-90/027F. Fourth Ed.

*Questions? Please E-mail: lazorchak.jim@epa.gov
[1] Presenter

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